

CPAP HUMIDIFIER

1                   CROSS-REFERENCE TO RELATED APPLICATION

2                 This application claims the benefit of U.S.

3                 Provisional Patent Application Serial No. 60/225,171

4                 filed on August 14, 2000.<sup>pro tem file</sup>

5                   BACKGROUND OF THE INVENTION

6                 Field of the Invention

7                 The present invention relates generally to a passive  
8                 humidification apparatus, and more specifically to a  
9                 humidifier for a continuous positive airway pressure  
10               (CPAP) device.

11               Relevant Prior Art

12               CPAP devices are now commonly used to treat a  
13               variety of respiratory disorders, including sleep apnea.  
14               CPAP devices normally consist of an air pump connected to  
15               a mask worn by a patient while they are sleeping.

16               Although CPAP devices have been very successful in  
17               treating these disorders, there is at least one  
18               associated drawback. The air that is introduced into the  
19               patient's respiratory system tends to have the effect of  
20               drying out mucous membranes. In order to mitigate this  
21               problem, several types of passive humidifiers have been

22               used in conjunction with the pump.

1           One such passive humidifier is disclosed in U.S.  
2    Patent No. 5,231,979 to Rose et al. This humidifier  
3    consists mainly of a chamber having an inlet and an  
4    outlet and that is partially filled with water. In  
5    operation, the outlet of a CPAP device is connected to  
6    the inlet of the humidifier and the mask is connected to  
7    the outlet of the humidifier. When the air supplied by  
8    the CPAP device enters the humidifier chamber and passes  
9    over and contacts the water, some moisture is added to  
10   the air through evaporation before the air ultimately  
11   passes to the mask and into the patient. This  
12   humidifier, however, is very ineffective and normally  
13   produces insufficient levels of humidity.

14           To improve the efficacy of the passive  
15    humidification system, some such humidifiers have been  
16    provided with baffles located within the humidifier  
17    chamber. One such baffled humidifier is disclosed in  
18    U.S. Patent No. 5,598,837 to Sirianne, Jr. et al. In  
19    this humidifier, air is made to flow around the baffles  
20    which increases its length of contact with the water and  
21    also tends to augment the evaporation process. However,  
22    this humidifier design still falls short of providing an  
23    optimum level of moisture in the output air.  
24    Additionally, the shape of this humidifier precludes most

1 system.

2 BRIEF SUMMARY OF THE INVENTION

3 According to one aspect of the present invention, a  
4 humidifier for a continuous positive airway pressure  
5 device is provided. The humidifier comprises a  
6 humidifier body, an air inlet provided to the humidifier  
7 body, an air outlet provided to the humidifier body, and  
8 a plurality of chambers defined within the humidifier  
9 body. The humidifier further comprises a plurality of  
10 baffles between one of the plurality of chambers and an  
11 adjacent one of the plurality of chambers, an opening  
12 provided between two of the plurality of baffles, the  
13 opening connecting the adjacent two of said plurality of  
14 chambers, and a deflector baffle being one of the  
15 plurality of baffles, the deflector baffle being located  
16 proximate to the opening and defining a serpentine fluid  
17 flow path between the adjacent chambers.

18 According to another aspect of the present  
19 invention, a humidifier comprises a non-planar dividing  
20 wall separating an adjacent two of said plurality of  
21 chambers, and an opening in the dividing wall providing  
22 fluid communication between chambers.

23 According to a further aspect of the present

1 cover to the base, a chamber defined by the base and  
2 cover, an inlet in communication with the chamber, and an  
3 outlet in communication with the chamber.

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 FIG. 1 is perspective view of a CPAP humidifier  
6 according to an embodiment the present invention;

7 FIG. 2 is plan view of the CPAP humidifier of FIG.  
8 1;

9 FIG. 3 is a plan view of a cover portion of the CPAP  
10 humidifier of FIG. 1;

11 FIG. 4 is a perspective view of the cover portion of  
12 FIG. 3;

13 FIG. 5 is a detail of air flow within a CPAP  
14 humidifier according to an embodiment of present  
15 invention;

16 FIG. 6 is a sectional view taken along section line  
17 6-6 of the CPAP humidifier shown in FIG. 2;

18 FIG. 7 is a sectional detail showing a seam of the  
19 CPAP humidifier of FIG. 6;

20 FIG. 8 is a perspective view of a CPAP humidifier  
21 according to another embodiment of the present invention;  
22 and

23 FIG. 9 is a sectional detail taken along section

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## DETAILED DESCRIPTION

2        In a passive humidification system, factors  
3        contributing to humidification include increased surface  
4        contact and decreased air pressure. By controlling these  
5        factors through humidifier design, the overall  
6        performance of the humidifier can be increased.

7        One way to positively affect both of these factors  
8        is by preventing laminar air flow through the system.  
9        When turbulence is introduced, the air does not travel in  
10      a straight line, and thus it will remain in the system  
11      longer and have increased surface contact with the water.  
12      Furthermore, assuming a constant input and output  
13      pressure, turbulent flow has the effect of increasing  
14      airflow velocity within the system. When the velocity of  
15      the air flowing across the surface of the water is  
16      increased, the air pressure above the water  
17      correspondingly decreases which effectively increases the  
18      rate of evaporation. Turbulent airflow can be created in  
19      several ways.

20       One way to create turbulence in a system is by  
21      designing the system with a high Reynolds number. As  
22      will be appreciated by one skilled in the art, the higher  
23      the Reynolds number, the greater the incidence of  
24      turbulent flow. The Reynolds number of a system is

1       inlet, thereby increasing the velocity of the air  
2       traveling through it.

3           Another way to increase turbulence and air velocity  
4       is by providing baffles that redirect the airflow.  
5       Further, by constricting the airflow space, the baffles  
6       will tend to increase the Reynolds number of the system.

7           As will be shown below, the shape and placement of  
8       baffles in the system are critical to providing the  
9       desired effect.

10          FIGS. 1 and 2 show the exterior of a CPAP humidifier  
11       10 according to the present invention. The humidifier 10  
12       is provided with an air inlet 12, an air outlet 14, and a  
13       humidifier chamber 16. In use, the inlet 12 is connected  
14       to the outlet of a CPAP device (not shown) and the outlet  
15       14 is connected to a patient delivery device, such as a  
16       mask (not shown). Both of these connections are normally  
17       accomplished using flexible hose. As best seen in FIG.  
18       1, the humidifier 10 comprises a cover portion 18 and a  
19       base portion 20.

20          FIGS. 3-5 show the cover 18 of the humidifier 10  
21       removed from the base 20. The cover 18 is provided with  
22       a plurality of arced baffles 22. Alternatively, the  
23       baffles 22 could be curvilinear, flat or formed from a  
24       plurality of flat portions connected at an angle.

1 effectively divided into four separate parallel chambers  
2 24, 26, 28, 30. The term non-planar as used herein with  
3 reference to the dividing wall refers to a body that is  
4 made up of at least two separate components which are not  
5 coplanar with respect to one another. For example, the  
6 wall of the present embodiment comprises individual  
7 baffles 22 which are curved and/or angled with respect to  
8 one another.

9       The first chamber 24 is adjacent to the air inlet 12  
10 and the second chamber 26. The second chamber 26 is also  
11 adjacent to the third chamber 28. The third chamber 28  
12 is also adjacent to the fourth chamber 30. The forth  
13 chamber is also adjacent to the air outlet 14.

14       Openings 32 are provided between adjacent baffles 22  
15 to allow adjacent chambers 24-30 to communicate with one  
16 another. Further, the baffles 22 do not extend  
17 completely to the base 20, leaving a space connecting all  
18 of the chambers 24-30. Each of the openings 32,  
19 excluding one opening 34 that is in closest proximity to  
20 the air outlet 14, is provided with a deflector baffle 36  
21 spaced away from the opening 32. The deflector baffle 36  
22 is provided as part of the dividing wall and defines a  
23 serpentine flow path between two adjacent chambers. The  
24 term serpentine, as used herein, refers to a path which

1 opening 34.

2 As an alternative, a dividing wall could be provided  
3 that is single curvilinear baffle being provided with  
4 apertures to serve as openings 32. Thus, a non-planar  
5 dividing wall according to the present invention need not  
6 comprise separate baffles wherein the space between them  
7 provides the openings 32.

8 Additionally, an inlet baffle 38 is provided within  
9 the air inlet 12 to direct airflow toward the far end 40  
10 of the first chamber 24. This helps better distribute  
11 the air flow among all of the openings 32, since the air  
12 flow will naturally favor the openings 32 closest to the  
13 inlet 12.

14 In operation, the humidifier chamber 16 is filled  
15 through either the inlet 12 or the outlet 14 with the  
16 humidifier 10 oriented in a vertical position. As shown  
17 in FIGS. 1 and 2, the chamber 16 should be filled with  
18 water up to between a pair of fill lines 42 marked on the  
19 cover 18. The chamber 16 is made from a transparent  
20 material to allow for easy determination of the proper  
21 water level. The humidifier 10 is then placed in a  
22 horizontal position, so that the baffles 22 extend  
23 vertically.

24 Referring again to FIGS. 3-5, when air enters the

1 deflection and the inertia of the air molecules, the air  
2 is distributed along the length of the first chamber 24.  
3 Continued airflow from the inlet 12 forces the air toward  
4 the first set of baffles 22 and eventually through the  
5 openings 32.

6 The deflectors 36 create back-pressure and prevent  
7 the air from passing to the second chamber 26 too  
8 quickly. The deflectors 36 also direct the air outward  
9 from the openings 32 and around the arced baffles 22.  
10 This air movement continues through the second chamber 26  
11 and third chamber 28 until the air is finally pushed into  
12 the fourth chamber 30 and through the outlet 14.

13 As shown in FIG. 5, during the time when the air is  
14 with each chamber 24-30, a cooperation between the arced  
15 shape of the baffles 22, the position of the openings 32  
16 and the deflection of the deflectors 36 causes the  
17 airflow to enter in an indirect serpentine fashion and  
18 circle a number of times within each chamber 24-30 before  
19 it exits through the opening 32. The indirect airflow  
20 and circling or eddying 44 causes additional turbulence,  
21 resulting in increased airflow velocity and significantly  
22 extending the duration of contact between the air and  
23 water. All of these effects taken together lead to  
24 enhanced evaporation and humidification of the air within

1 enhance the eddy effect.

2        Since the baffles 22 do not extend fully to the base  
3 20, the water is free to flow within the chamber 16.  
4 This helps to further enhance evaporation and minimize  
5 the energy necessary to break water molecules away from  
6 the surface of the water by decreasing the effect of  
7 surface tension. Thus, as shown in FIG. 6, the direction  
8 of air flow tends to cause the water level in each  
9 successive chamber 24-30 to be higher than the previous  
10 one. For this reason, no deflector 36 is provided at  
11 opening 34, helping to prevent excess back-pressure from  
12 accumulating and causing water to be forced through the  
13 outlet 14.

14       Further, both the inlet 12 and the outlet 14 are  
15 raised above the top of the cover 18 to help prevent  
16 water from inadvertently flowing out of the chamber 16.

17       In addition to humidifier efficiency, the design of  
18 the humidifier 10 is based on some other considerations.  
19 The cover 18 is provided with lateral ribs 48 that  
20 provide help to stiffen the surface of the cover 18.  
21 This, along with the flat top design of the cover 18,  
22 allow a CPAP device to be placed on top of the humidifier  
23 to minimize the overall footprint. The ribs 48 have been  
24 strategically positioned to help trap airflow and to some

1 provide additional strength. This ribbing 50 is designed  
2 to mirror the baffles 22 within the chamber 16 for purely  
3 aesthetic reasons.

4 As shown in FIGS. 1-2, the cover 18 can be  
5 molded from a single piece of rigid plastic and  
6 permanently secured to the base 20. As shown in FIG. 7,  
7 the cover 18 is secured to the base 20 using a permanent  
8 adhesive 52. Since many prior art devices are clamped  
9 together and sealed with a flexible gasket, they are more  
10 prone to leakage. To further prevent leakage, a tongue  
11 54 provided on the cover 18 fits into a groove 56  
12 provided on the base 20 and the adhesive 52 fills a void  
13 58 between the tongue and the groove. Excess adhesive 52  
14 flows into gaps 60 that remain between the cover 18 and  
15 the base 20.

16 Alternatively, as shown in FIG. 8, a removable cover  
17 18' can be used. The removable cover 18' is formed as  
18 two-piece structure. A main cover portion 18a is formed  
19 from rigid material, like that of the one-piece cover 18.  
20 The main portion 18a is surrounded by a sealing cover  
21 portion 18b that is formed from a flexible material, such  
22 as rubber, molded around the main portion 18a. The  
23 flexible sealing portion 18b forms a sufficiently air and  
24 water tight seal with a modified base 20', but is

1       resilient nature of the sealing portion 18b keeps the  
2       cover 18' securely in place on the base 20'.

3       Alternatively, the cover 18' could be constructed as a  
4       single piece.

5           As shown in FIGS. 9 and 10, the base 20' has a  
6       ribbed projection 62 which extends around the top edge of  
7       the base 20'. The projection 62 snaps into a  
8       corresponding recess 64 on provided in the bottom edge of  
9       the sealing portion 18b. A tab 66 is provided on the  
10      sealing portion 18b to allow the sealing portion 18b to  
11      be deformed by manually applied pressure, breaking the  
12      seal and allowing removal of the cover 18'.

13          Further, because CPAP devices generally contain  
14       electric motors, they tend to produce heat when run  
15       continuously. By placing a CPAP device on top of the  
16       humidifier chamber 16, some heat may be transferred to  
17       the water, thereby increasing the rate of evaporation.

18          To further enhance humidification, a separate heater  
19       (not shown) could be provided to the humidifier 10.  
20       Although heaters are well known for use with humidifiers,  
21       a heater used with the present design would adequately  
22       work at lower temperature than in prior art devices.  
23       Lower temperatures generally provide safer operation.

24          It should be evident that this disclosure is by way

1 departing from the fair scope of the teaching contained  
2 in this disclosure. The invention is therefore not  
3 limited to particular details of this disclosure except  
4 to the extent that the following claims are necessarily  
5 so limited.